REMARKS

In response to the Official Action mailed May 22, 2003, Applicants amend their application and request reconsideration. In this Amendment claims 5 and 6 and non-elected claims 18-20 are cancelled. No new claims are added. Accordingly, claims 1-4 and 7-17 are now pending.

In this Amendment all remaining claims have been amended for clarity. In addition, claim 11 has been re-written in independent form, again with substantial clarification. Claim 16, an examined independent claim, incorporates amended claim 1. Amended claims 1 and 16 respectfully describe an optical modulator and photonic semiconductor device including an optical waveguide ridge. The ridge includes several layers. One of those layers is a first cladding layer. In the claimed structure, the first cladding layer protrudes from the optical waveguide ridge and covers part of the principal plane of the semi-insulating semiconductor substrate. This structure is described in the patent application, among other places, at page 12, lines 5 and 6, and at page 17, lines 13-17. In depicted embodiments of the invention (see, for example, Figure 2), the extension is element 26a.

Examined claim 1 was subjected to two different rejections. In the first of the rejections, claim 1 was rejected as unpatentable over Terakado (JP 3-263388)[1] in view of Sano et al. (U.S. Patent 5,339,370, hereinafter Sano). In the second of the rejections, claim 1 was rejected as unpatentable over Sano in view of Soref (U.S. Patent 5,838,870), and further in view of Huang (U.S. Patent 6,222,951). Claim 16, which includes all of the limitations of amended claim 1, was subjected to the same two rejections with the addition of Koui (U.S. Patent 5,918,109). All of rejections are respectfully traversed.

The rejections are respectfully traversed because combination of references is not proper and, if combined, do not illustrate or suggest a modulator structure as in claim 1.

As described above, the structure of the claimed optical modulator includes an extension protruding from the optical waveguide ridge and covering a part of the principal plane of the semiconductor substrate. As described at page 17 of the patent application, the extension helps avoid an increase in the capacitance of the optical modulator. As well known to those of skill in the art, the capacitance of a semiconductor device directly affects the ability of the semiconductor device to operate at an high frequency. Therefore, in order to increase the frequency range of operation, including the speed of switching, it is important to keep the capacitance low and to, if possible, lower the capacitance of the device. The result is achieved in the invention as described by amended claim 1.

[1] Terakado corresponds to part of the disclosure of U.S. Patent 5,825,047.

Unlike the invention, one of the connections employed in the optical modulator described by Terakado includes an air bridge. The air bridge is visible in Figures 1 and 3 of Terakado. The air bridge includes an electrical connection to the top of a ridge but the part of the electrical connection from that electrode to a bonding pad 15 is spaced from a sidewall of the mesa. The spacing of the air bridge is achieved in the process illustrated in Figures 2(a)-2(c) of Terakado. Two layers of metal are deposited on a temporary support 11 that is subsequently removed to provide the spacing of the air bridge. By contrast, in the invention, the corresponding electrical connection is in contact with the side surface of the optical waveguide ridge and electrically insulated from that waveguide ridge by a dielectric film.

Sano describes an electrode 10 supported by a dielectric film 9-2 that covers a side surface of a ridge of an optical modulator. In making the rejection, the Examiner hypothesized that it would have been obvious to modify Okanado by replacing the air bridge with the direct contact support of the electrode 9-2 of Sano because fewer steps in the manufacturing process are required than if the air bridge structure is used. Applicants respectfully disagree.

First, the structure of the mesa in Terakado is substantially different from the optical waveguide ridge of the invention and Sano. In the mesa of Terakado, there are layers of iron-doped InP that sandwich the optical ridge. The presence of these layers changes the capacitance of the structure and encourages Terakado to reduce the capacitance of the structure by separating the electrode layer from the mesa. On the other hand, Sano provides a metal layer in contact with the side surface of the optical ridge, separated only by an insulating film. Thus, Terakado and Sano provide different teachings for reducing the capacitance of the electrode connection. Because of these different approaches, one of skill in the art would not seek to combine Terakado and Sano. In other words, there is no motivation for the asserted combination of references so that the rejection is erroneous.

Even if Terakado and Sano could be combined, Sano includes no suggestion for reducing the capacitance between its metal layer 10 and the back electrode 8 on the rear surface of the substrate 7. In fact, because of the arrangement described by Sano including the electrical circuit illustrated on the first page of that patent, it is apparent that Sano's substrate 7 cannot be a semi-insulating substrate. That substrate must conduct a current flow, unlike the semi-insulating substrate of the invention. The presence of the contact 8 in Sano increases the capacitance of the entire structure, further demonstrating that there would be no motivation to modify Terakado with Sano because Terakado provides a technique for reducing capacitance of the electrode structure while the structure of Sano only increases that capacitance. Absent motivation to combine the two references, the invention as defined by

amended claim 1 cannot be suggested by the two references, even if the two references some how, in combination, included all of the elements of amended claim 1.

In the second rejection, claim 1 was rejected based upon the asserted combination of Sano, Soref, and Huang. However, this combination of references cannot suggest the invention as defined by amended claim 1.

As already described, an important advantage of the invention as defined by amended claim 1 is a reduction in the capacitance of the optical modulator. Part of this capacitance reduction is provided by the structure of the bonding pad of the first electrode. The references do not suggest the capacitance-reducing structure of that bonding pad of amended claim 1.

The structure described in Sano does not include a second opening in the dielectric layer opposite a region of the extension of the first cladding layer on the second side of the optical waveguide ridge as in claim 1. Moreover, Sano does not describe an opening corresponding to the second opening in the dielectric layer of claim 1, through which the second electrode makes contact to the first cladding layer. Sano would not be expected to include this opening and contact because it does not employ, as in the invention, a semi-insulating substrate.

In order to fill one of the voids between the structure of claim 1 and Sano, reliance was placed upon Figure 2e of Soref. In the structure shown in that figure, as noted by the Examiner, there is a second opening in an outer dielectric layer providing contact between the second electrode and the first cladding layer. Soref employs a silicon substrate 6, not a semi-insulating substrate. Thus, Soref is substantially different in structure from Sano and cannot suggest the modification of Sano as asserted by the Examiner.

More importantly, as already noted, an important feature and advantage of the invention is a reduction of the capacitance of the claimed optical modulator. There is no similar reduction in capacitance in the optical modulator of Sano because of the large metal layer 10 on the rear surface of the substrate. While Soref may describe a ridge waveguide including a second opening in an outer dielectric layer through which the second electrode can contact the first cladding layer, Soref does not describe that the first electrode extends on the first side of the optical waveguide ridge, in contact with the dielectric film that is on that side of the waveguide ridge. Therefore, Soref cannot achieve a reduction in capacitance of the bonding pad of the first electrode and cannot achieve the important advantages of the present invention.

Huang only describes the use of electrodes on the top of a substrate region that extends through openings of a dielectric layer. Huang is totally silent with regard to reducing

capacitance of an optical modulator, thereby increasing high-speed performance. Accordingly, there is no motivation for combining the three references. Therefore, the second rejection with regard to claim 1 should be withdrawn.

In summary, because of the improvements provided by the structure of amended claim 1 and because the elements of that structure are not described in any potential combination of the references applied in the two rejections of claim 1, that claim and its dependent claims 2-4, 7-10, and 12-14, should now be allowed. In addition, amended claim 16, which incorporates the limitation of amended claim 1, should likewise be allowed along with its dependent claim 17.

As noted, in rejecting claims 16 and 17, further reliance was placed upon Koui as showing, integrated on the same substrate, a semiconductor laser and an optical modulator. However, since Koui lacks the electrode structure of amended claim 1, it cannot supply those parts of the claimed modulator and photonic device of claims 1 and 16 and of other claims and, therefore, cannot establish *prima facie* obviousness of either of claims 16 or 17.

Yamanishi et al. (U.S. Patent 5,173,955) was cited as illustrating in its Figure 11 a light modulator structure including an electrode disposed not only on top of a ridge but on both sides of the ridge. Again, the electrode structure of amended claim 1 is not present in Yamanishi so that Yamanishi, while potentially pertinent to the limitations of claims 2, 4, 8 and 10, cannot, in combination with the other groups of references applied in rejecting amended claim 1, establish *prima facie* obviousness of that claim nor of any of its dependent claim.

Yamada et al. (U.S. Patent 6,374,028), cited in rejecting claims 12-14, does not, in combination with Terakado, Sano, Soref, and Huang supply the electrode structure described in amended claim 1 and claim 16. For the foregoing reasons, it is apparent that claim 1 and its dependent claims, as well as claim 16 and its dependent claim 17, are patentable over any potential combination of the references applied in rejecting the examined claims. Therefore, those claims should now be allowed.

Examined claim 11 was rejected based upon the same two rejections applied in rejecting examined claim 1. Applicants again respectfully traverse those rejections as to amended claim 11.

As already mentioned, claim 11 pertains to the structure in which the semiconductor substrate, while semi-insulating elsewhere, includes a doped region that provides an electrical connection to the first cladding layer of the optical waveguide structure. The claim encompasses the embodiment of Figure 13. As in the rejection of claim 1, the rejection of claim 11 is not set forth in detail in the Official Action. In fact, a careful review of each of

the five references employed in the two rejections of claim 11 fails to disclose any contact structure including a doped portion of a semi-insulating substrate as in the structure of claim 11. The comments at page 6 of the Official Action concerning both claims 3 and 11 seem only directed to the structure of examined claim 3 and not to the structure of examined or amended claim 11. Accordingly, upon reconsideration, claim 11 should be allowed.

Reconsideration and the withdrawal of the rejections as to the claims now pending, as well as allowance of all of those pending claims, are earnestly solicited.

Respectfully submitted,

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